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NOTES ON THE ALGAE FROM AN ALASKAN OXIDATION POND WITH THE DESCRIPTION OF A NEW GENUS

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From May through December 1963, one of us (D. K. H.) conducted a weekly sampling program in order to learn something of the performance capabilities of a sewage oxidation pond situated in south central Alaska at 61° 37' N, 149° 2' W. An account has previously been given describing the pond with comments on its efficacy (cf. Hilliard, 1964), and notes on its ecosystem are in progress (Hilliard, in prep.). It is the purpose of this paper to present a systematic account of the algal flora occurring in this pond.

Description

The oxidation pond, receiving raw sewage from a community of 36 people, passes directly into a rectangular catchment having an area of 0.07 hectare and a mean depth of 51 cm. As there is no outlet, liquid losses are dependent on evaporation and seepage. The pond floor and dikes are composed of mineral earth and gravel. During the winter, ice forms within 2.5 cm of the bottom.

Methods

Samples for analyses were collected at a depth of 5 to 10 cm with a 3.5 liter plastic bottle. Chemical analyses were performed according to the recommendations of Standard Methods for the Analysis of Water and Sewage (1960). Dissolved oxygen was determined by the modified (Alsterberg) Winker method. pH measurements were done electrometrically. Monthly averages for the principal chemical determinations are given in Table I.

Plankton samples were gathered within the upper 10 cm of the pond at a distance of about 2 meters from the shore. Living material was examined within a few hours, while additional material was preserved in Rohde's solution for further study. Enumeration was done by using the Sedgwick—Rager cell for the larger species, and the Utermöhl counting chamber for the more minute forms. Due to the general abundance of algae, centrifugation was not required.

The Algal Flora

Detailed accounts of 14 taxa, including a new genus and a new species, are presented. This list is not complete, since it was based upon only one sample for each month of the growing season (May through December). In addition, the following volvocalian forms were identified from our material by Dr. H. Ettl.

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In May, shortly after the ice melted, the following forms made their appearance:

Chlamydomonas globosa Snow, *Ch. heterogama* Gerl., *Ch. isogama* Korsch., *Ch. oblonga* Skvortz. (also in August), *Ch. paludosa* Skvortz., *Ch. perpusilla* Gerl., *Ch. Reinhardi* Dang. (this was the most abundant of any of the chlamydomonads and was observed also in June and Oktober), *Ch. Reinhardii* var. *minor* Nyg. (the small form was seen also in August and September), *Ch. simplex* Pasch., and *Diplostauron pentagonium* Pasch. Only during October did *Ch. applanta* Prings. and *Chlorogonium fusiforme* Matw. appear, while in mid-August *Haematococcus draebakensis* Wollenw. was second in dominance to *Scenedesmus acutus*. Apart from the above cited volvocalian taxa, a Chrysophyte, *Ochromonas* sp., was observed briefly during mid-August. This alga, which measures 4 × 6 μ, falls within the size range of both *Ochromonas minuscula* Conr. and *Ochromonas gracilis* Doft., but the length of its flagella with respect to cell length differs appreciably from that of the later species, hence its taxonomic position is uncertain.

Detailed Account

Schizomycophyta

1. *Chloronostoc abbreviatum* Pasch.

Figs 42—43.

Filaments variously bent; cells spherical and measuring 1 μ in diameter Light bluish-green. Occurrence: August through December.

Cyanophyta

Campylotropium n. gen. Hortob. et Hilliard

Figs 1—18.

Cells bent with rounded ends and of uniform thickness. They occur mostly in spherical colonies comprising many cells; individual cells are rarely observed. The cells are individually covered with a colourless mucilaginous integument; no common integument was observed for the colonies. Multiplication by cell-division.

2. **Campylotropium alascense** n. sp. Hortob. et Hilliard

Cells more or less bent, but never straight; length 3.7—8.3 μ, width 0.6—0.8 μ. Uniform, with rounded ends. Cell content homogenous and light blue. Individual cells covered with colourless, mucilaginous integument equal to cell width in thickness; no common integument present. The spherical colonies comprised of a relatively small number of cells which adhere to each other with their mucilaginous covering. Multiplication by dichotomy.

The cell shape of this new alga is reminiscent of some species belonging to the genus *Gloeotheca* e. g., *Gl. vibrio* N. Carter, *Gl. linearis* Näg., the genus *Rhabdoderma e. g. Rh. vermicularis* Fott, *Cyanarcus hamiformis* Pascher. It differs from the former two genera by the absence of a common mucilaginous integument and by the shape of its colony; however, if differs from *Cyanarcus*, in shape of its colonies and in the presence of a mucilaginous sheath surrounding the individual cells.

The cells of the new species when viewed individually, and separated from their colony, resemble those belonging to the genus *Romeria*, especially *Romeria elegans* Wolosz. whose mucilaginous integument is quite similar to that of the new species.

From an evolutionary point of view, it would appear that a close relationship exists between the Hormoginales *Romeria* and the new species which belongs to the order Chroococcales.

The new genus is undoubtedly a member of the Chroocaccales and is to be compared with other cyanophytan genera bearing spherical colonies, e.g. *Gomphosphaeria*, *Marssoniella*, *Coelosphaerium*, and *Woronichinia*. It differs from the aforementioned genera however, by the absence of a common mucilaginous integument.

Occurrence: from September through December; most common in October, however, characteristic forms are found during December.

Diagnosis:

Campylotropium n. gen.

Figs 1—18

Cellulae plus minus inclinatae, nunquam rectae, 3.7 — 8.3 × 0.6 — 0.8 μ, aequaliter crassae, apicibus rotundatae, materiam pallide coeruleam homogeneam continentes, indumento ex muco hyalino, latitudine cellularum aequaliter crasso singillatim circumdatae, et per ipsum inter se conglutinatae, sine muco communi, plerumque pro ratione paucae in coloniis sphaeroideis, raro singillatim dispositae; per divisionem multiplicantur.

Campylotropium alascense n. sp.

Cellulae inclinatae, apicibus rotundatae, aequaliter crassae, plerumque in coloniis sphaeroideis, raro singillatim dispositae, muco hyalino singillatim circumdatae, sine muco communi; per divisionem multiplicantur.

3. *Oscillatoria limnetica* Lemm.

Figs 19—23

Trichomes straight or bent, cells 3.7—11 × 1.2 μ, greenish-blue. In June cell ends possessed 1—1 large cyanophycin spheres. Occurrence: June, September—December.

4. *Spirulina abbreviata* Lemm. f. *minor* Hortob.

Figs 27, 36—41

Trichomes 4—11 × 1—1.2 μ. Spiral 2 μ wide. Cell cross-walls rarely seen; trichomes with ½—1 coils, very seldom straight. One straight specimen was obeserved in September. A nannocytical form was noted in May. Occurrence: May through December.

This form was first described from Hungary (Nagyfa: Dead branch of Tisza river, 1939), and has also been observed in several fish-ponds in that country. The Hungarian specimens measure 7.5—19 × 0.8—2.5 μ, while those from Alaska are slightly smaller.

5. *Spirulina laxissima* G. S. West

Figs 28—35

Trichomes 6—25 × 0.7 μ. Specimens nearly straight to regularly coiled. Cross-walls rarely seen. Nannocytical filaments observed in autumn samples. Spirals 2.5—5.3 μ wide, distance between spirals 8—12 μ. Appearance quite variable. Occurrence: May, September through December.

6. *Spirulina Meneghiniana* Zanard. f. *minor* Hortob.

Figs 24—26

Trichomes 8.7—19 × 0.8 μ. Number of spirals 1—4, spiral width 2.5 μ distance between spirals 4.5—5 μ. A nannocytical trichome observed in May Occurrence: May through July; September through November.

Chlorophyta

7. *Chlamydomonas biverruca* Pasch.

Figs 44—45

Cells oval, 12—13 × 10—10.4 μ. Slightly smaller than the type specimens Occurrence: July and August.

8. *Chlamydomonas* sp. I.

Figs 46—51

Cells variable; globose, depressed globose to oval. Chloroplast beaker form; pyrenoid ventrally situated. Flagella longer than body length. Cell diameter 7—11 μ. Stigma not observed. Occurrence: May.

9. *Chlamydomonas* sp. II.

Cells extended with lower portion terminating in an obtuse apex. Two apical papillae form a base for the flagella. Two large pyrenoids occupy much of the cell. Cells 22—33,8×19,5—29μ. Occurrence: August.

10. *Ankistrodesmus falcatus* (Corda) Ralfs var. *acicularis* (A. Br.) G. S. West

Fig. 53

Cells 20.8×1 μ. Occurrence: August.

11. *Ankistrodesmus falcatus* (Corda) Ralfs var. *spirilliformis* G. S. West

Figs 54—58

Cells variously curved, 7—21×0.7 —μ. Occurrence: May through December.

12. *Closteriococcus viernheimensis* Schmidle

Fig. 52

A single specimen was noted in May. Cell 16×3.7 μ; slightly thickened at the ends.

13. *Micractinium pusillum* Fres.

Cells 8—9.5 μ in diameter. Setae length to 40 μ. Occurrence: August.

14. *Scenedesmus acutus* Meyen

Figs 59—158

Cells fusiform, smooth walled, and with obtuse spices whose membrane may be slightly thickened; measure 7.5—18.5×2.2—9 μ. Mucilaginous integument lacking. Unicellular forms dominant, but 2-, 4- and 8-celled coenobia present in small numbers. Coenobia composed of cells arranged in a single, double, alternating or irregularly alternating series. Occurrence: May through December.

This plant demonstrated extreme pleomorphism, occurring principally in the monodesmoid form with intergrades up to an 8-celled coenobium (cf. Table I).

Table I

Average monthly values in mg/l

	Month							
	V	VI	VII	VIII	IX	X.	XI.	XII.
pH-range	6.9—10.4	8.8—10.8	7.4—10.9	7.4—10.5	9.4—11.2	8.6—9.1	7.8—8.9	7.8—8.7
Oxygen ...	0.15—29.4	12.3—15.7	0.2—17.4	1.1—33	11.6—16.1	4.6—9.9	0—1.5	0—1.5
Chlorides ..	11.9	23.7	34.1	36.6	28.5	35.4	62	98
NO_3—N ..	0.5	0.9	0.9	0.4	0.5	0.5	0.3	0.3
O—N	11.1	11.5	14	8.5	4.5	2.2	2	7.3
NH_3--N ...	6.8	4.3	3.5	8.5	4.8	15.2	47	118
PO_4	3.9	7.8	7.8	5.9	11	15	28	49
5-day BOD	12.1	22	18	35	30	37	40	146

Irregular groups and parenchymatic agglomerations of cells were observed throughout October and November. Also in October, cells comprising the coenobia were found to be alternately situated, but this was not observed in other months. Eight-celled coenobia appeared only during the month of August, during which time they were second in abundance only to the unicellular forms.

The 8-celled coenobia are in some respects comparable to *Scenedesmus acutus* f. *alternans* Hortob., and to the coenobia of *Scenedesmus costulatus* Chod., as both colonies contain two series of cells of which 4 or 6 of the intermediate cells are closely appressed, while those at the extremes appear to b loosely attached. The series of cells thus comprising the coenobia may be straigh

Table II

Variability in numbers of cells per coenobia as shown by percentage of occurrence
(Scenedesmus acutus Meyen)

Cells per coenobia	Month							
	V.	VI.	VII.	VIII.	IX.	X.	XI.	XI .
Unicellular	99	95	98	81.8	94	96.8	98	99.4
2-celled	0.4	2.6	1.1	3.4	2.5	2.4	1.6	0.6
3-celled	+	0.4	0.5	1.4	0.5	0.2	+	+
4-celled	0.3	2	0.4	1.2	3	0.6	0.4	+
5-celled	—	—	—	0.6	—	—	—	—
6-celled	+	—	—	+	—	—	—	—
7-celled	+	—	—	+	—	—	—	—
8-celled	—	—	—	11.6	—	—	—	—

r curved; the cells may be closely or loosely attached, or they may occur eparately. We have observed all the transitional forms between the typical *costulatus*" and "*alternans*". Judging from the large number of 8-celled oenobia observed during August, we concur that Chodat's views regarding *costulatus*" appear to be incorrect. Uherkovich (unpublished thesis) stated hat "*costulatus*" cannot be accepted as a valid species in light of Grossmann's 1920) finding in experimental cultures. Moreover Uhrekovich combined *cenedesmus costulatus* and *Scenedesmus acutus* f. *alternans* as *Scenedesmus cutus* var. *costulatus* nov. comb. There is, however, some question as to hether this taxon is valid, since it appears that it could be considered at most o be a form.

The unicellular form of *Scenedesmus acutus* was dominant throughout he growing season; there followed, in descending order of abundance, the -celled coenobia, then the 2- and 4-celled colonies. The last named were fairly ommon. The unicellular forms multiply in the same manner as cells in coloies; i. e., either 8-celled coenobia or unicells may originate from them.

In May, there appeared many minute *Scenedesmus* cells measuring —4 μ. These microfragments, already known from the literature, are recogized as being autospores of small size, and may be considered analogous with he nannocytes of the *Cyanophyta*. These were not observed during the other onths, however.

The pleomorphic coenobia and cells were quite common, and we consider oenobia deviating from the normal number of cells to be abnormal. Due to heir pleomorphism, many of the cells have assumed shapes which are remiiscent of those of other genera. For example, the bicellular colony (cf. Fig. 36), suggests *Ankistrodesmus falcatus* (Corda) Ralfs var. *duplex* (Kützing) . W. West; while colonies seen in Figs. 141, 150 are similar to *Actinastra*, and volutionary connection between the genera *Tatraëdron*, *Kirchneriella*, *Selenstrum*, *Oocystis* and *Nephrochlamys* on the one hand, and the Scenedesmi n the other. The parenchymoid grouping of cells in one or more layers, someimes comprising several hundreds of cells, may likewise be considered anoalous.

Cells of *Scenedesmus* considered to be abnormal occur commonly in culures. This phenomenon was first reported by Famintzin (1871) while using edia of different concentrations. Later Beyerinck (1890) found that *S. cutus* demonstrated a variety of forms as a result of employing different ulturing methods, while Senn (1899) observed similar results when he used ineral salts. Grossmann (op. cit.) suggests that the alternation of shape in *. acutus* was induced by Knop solution. The pleomorphism of *Scenedesmus* as discussed in detail by Chodat and his collaborators also (1893, 1909, 1913). Iortobágyi (1960), in his investigation at Szilvásvárad in northern Hungary, ave a full account on the changes in *Scenedesmus* resulting in altering the

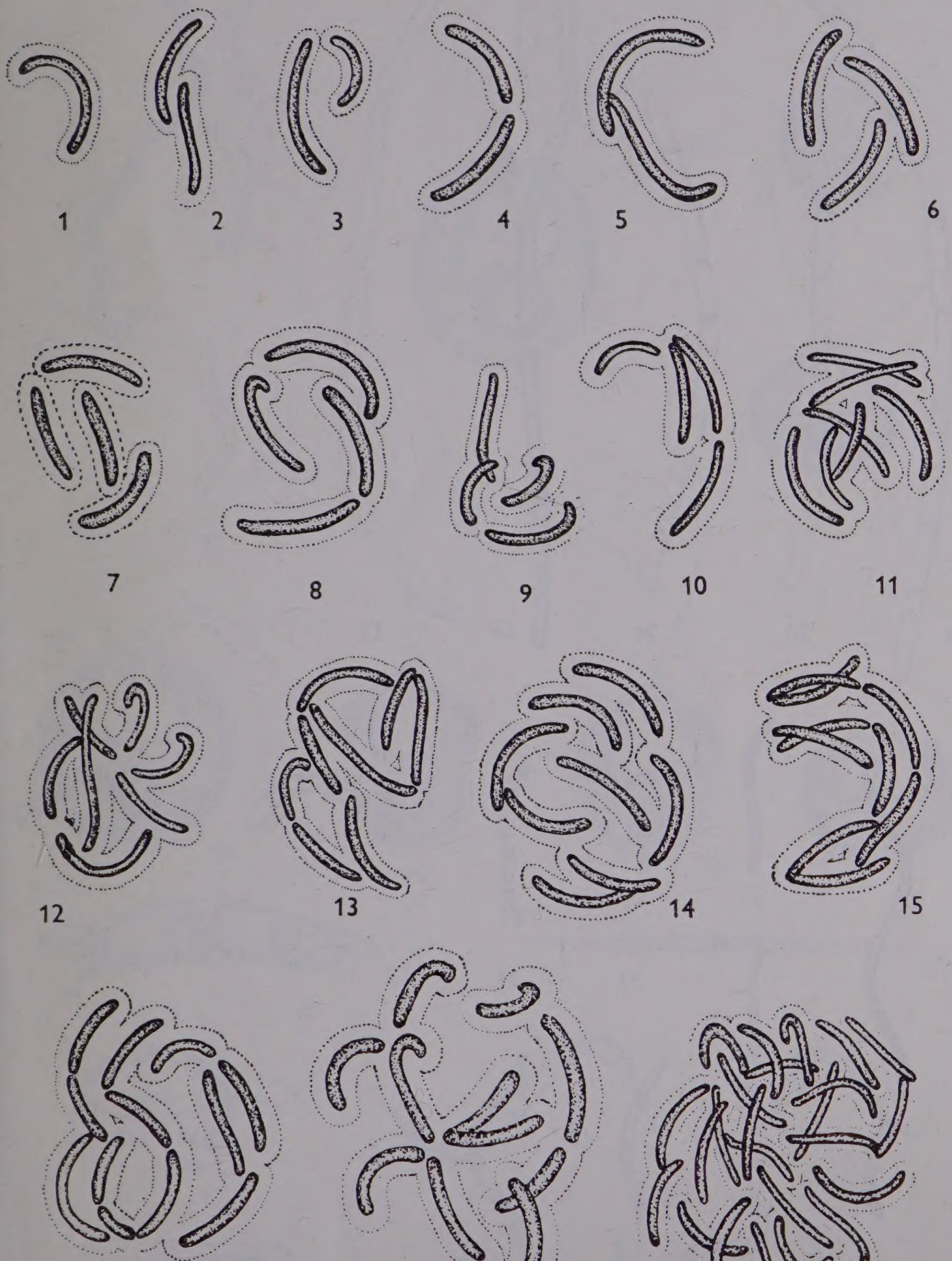
Table III

Species occurring in oxidation pond

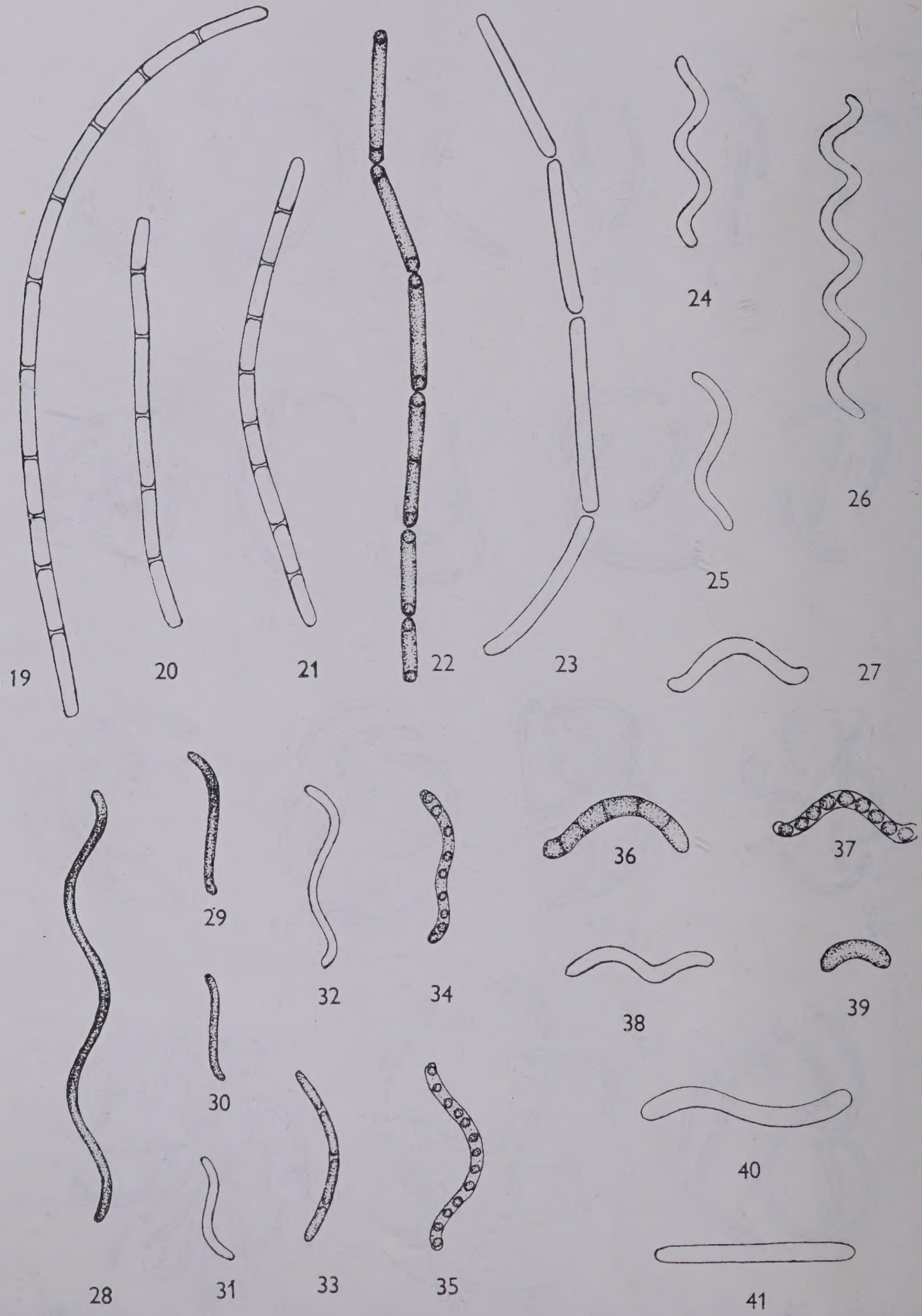
	Month							
	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Schizomycophyta								
Chlorobacteriales								
1. *Chloronostoc abbreviatum* Pascher				+	+	+	+	+
Cyanophyta								
Chroococcales								
2. *Campylotropium alascense* n. sp. Hortob. et Hilliard					+	+	+	+
Hormogonales								
3. *Oscillatoria limnetica* Lemm.		+			+	+	+	+
4. *Spirulina abbreviata* Lemm. f. *minor* Hortob.	+	+	+	+	+	+	+	+
5. *Spirulina laxissima* G. S. West	+				+	+	+	+
6. *Spirulina Meneghiana* Zanard f. *minor* Hortob.	+	+	+		+	+	+	
Chlorophyta								
Volvocales								
7. *Chlamydomonas biverruca* Pascher			+	+				
8. *Chlamydomonas* sp. I.	+							
9. *Chlamydomonas* sp. II.				+				
Chlorococcales								
10. *Ankistrodesmus falcatus* (Corda) Ralfs var. *acicularis* (A. Br.) G. S. West				+				
11. *Ankistrodesmus falcatus* (Corda) Ralfs var. *spirilliformis* G. S. West	+	+	+	+	+	+	+	+
12. *Closteriococcus viernheimensis* Schmidle	+							
13. *Micractinium pusillum* Fres.				+				
14. *Scenedesmus acutus* Meyen	+	+	+	+	+	+	+	+

concentration of media. More recently TRAINOR (1963, 1964) has noted ple morphic forms of *Scenedesmus* in axenic cultures.

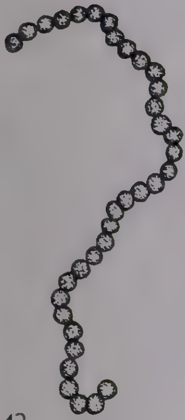
We feel that the material from Alaska is significant in that it represen *Scenedesmus* from a natural environment which exhibit a rate of cellul abnormality even greater than that observed in cultures.



Figs 1—18. Campylotropium alascense n. gen. et sp. Hortob. et Hilliard



Figs 19—23. Oscillatoria limnetica Lemm.
Figs 24—26. Spirulina Meneghiniana Zanard. f. *minor*. Hortob.
Fig. 27. Spirulina abbreviata Lemm. f. *minor* Hortob.
Figs 28—35. Spirulina laxissima G. S. West
Figs 36—41. Spirulina abbreviata Lemm. f. *minor* Hortob.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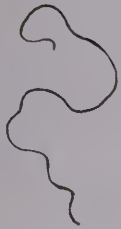
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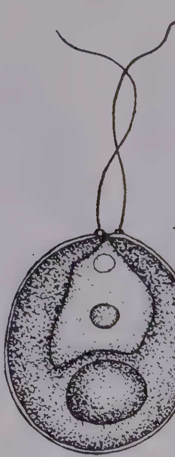
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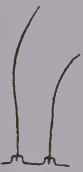
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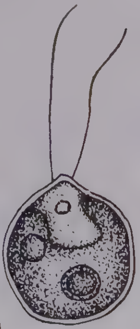
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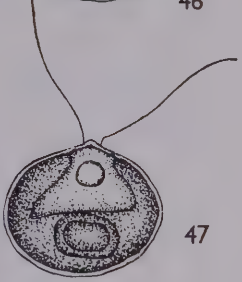
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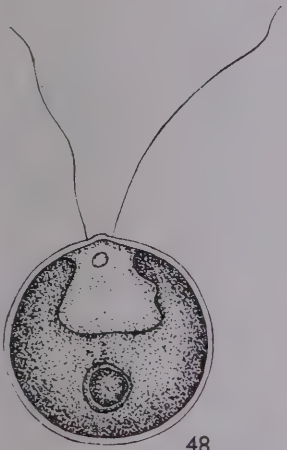
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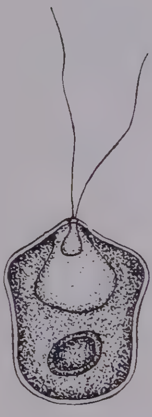
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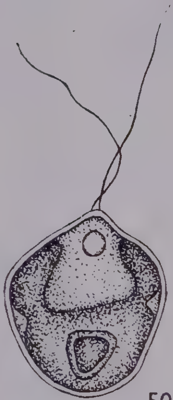
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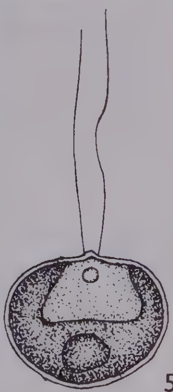
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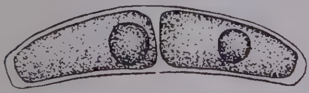
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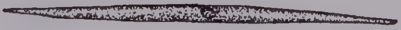
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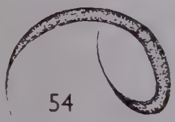
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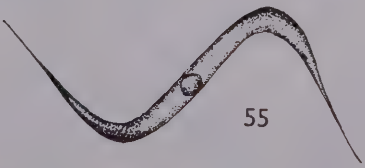
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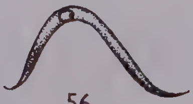
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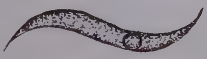
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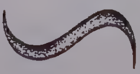
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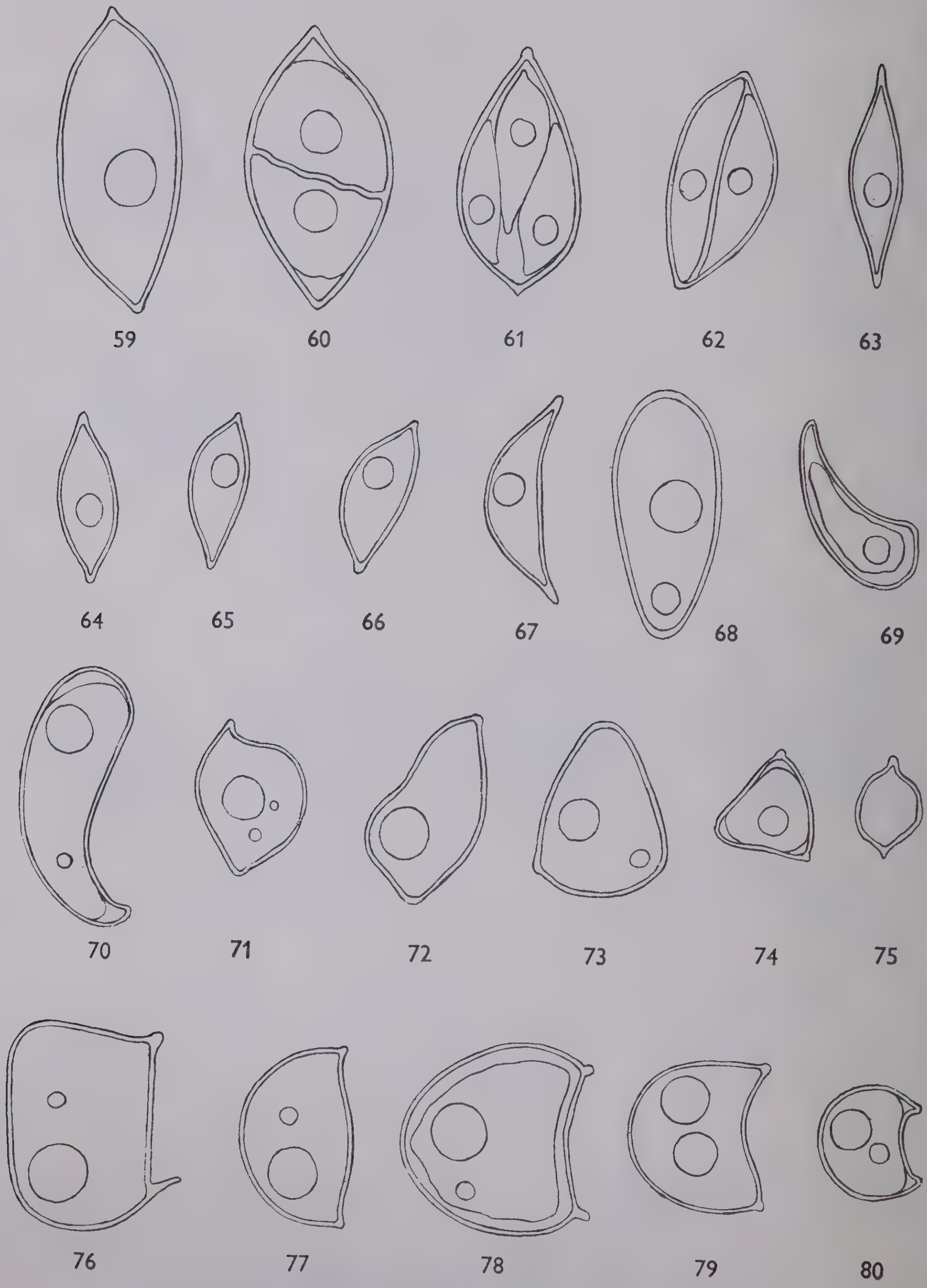
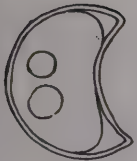
Figs 42–43. Chloronostoc abbreviatum Pasch.
Figs 44–45. Chlamydomonas biverruca Pasch.
Figs 46–51. Chlamydomonas sp. I.
Fig. 52. Closteriococcus viernheimensis Schmidle
Fig. 53. Ankistrodesmus falcatus (Corda) Ralfs var. *acicularis* (A. Br.) G. S. West
Figs 54–58. Ankistrodesmus falcatus (Corda) Ralfs var. *spirilliformis* G. S. West



Figs 59—158. Scenedesmus acutus Meyen
All figs × 3000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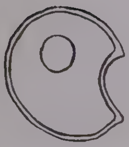
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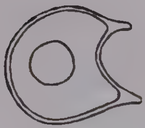
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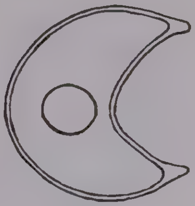
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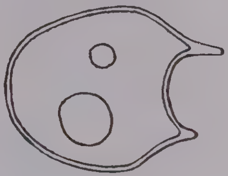
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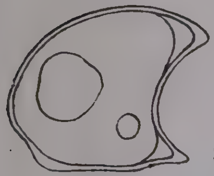
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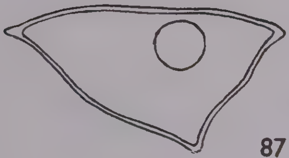
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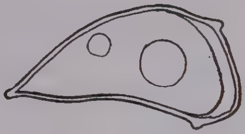
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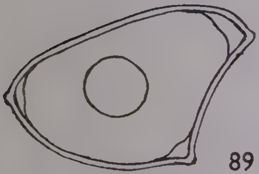
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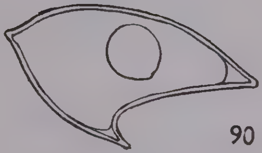
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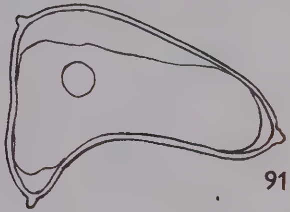
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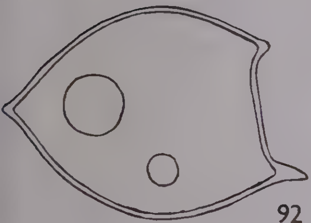
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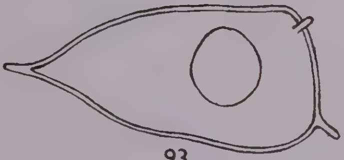
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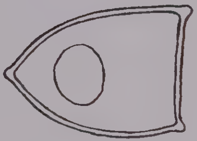
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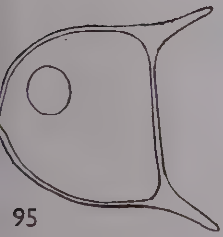
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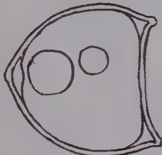
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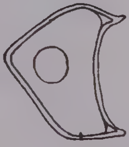
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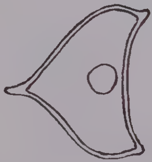
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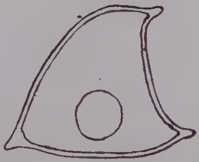
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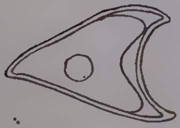
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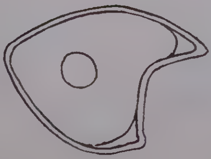
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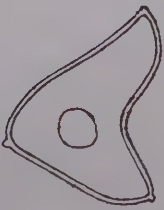
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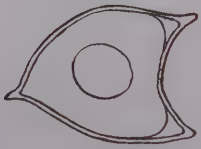
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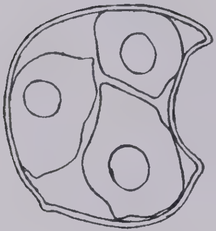
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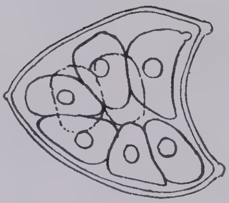
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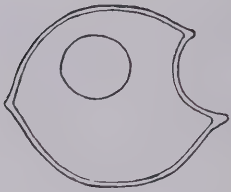
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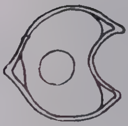
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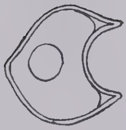
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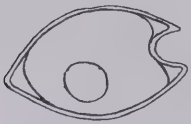
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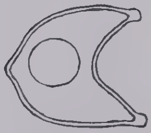
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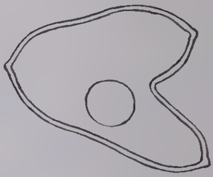
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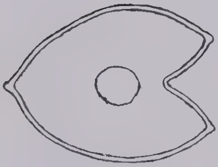
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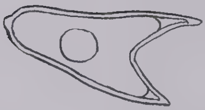
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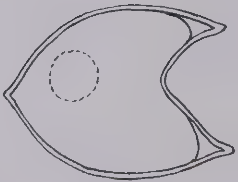
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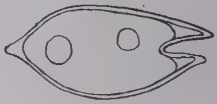
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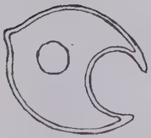
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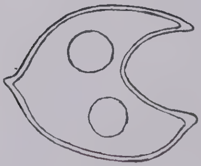
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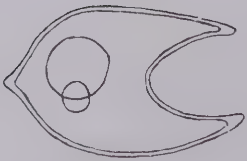
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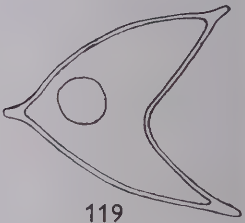
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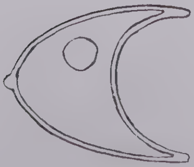
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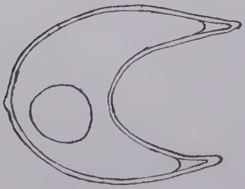
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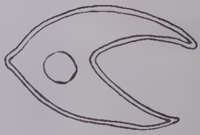
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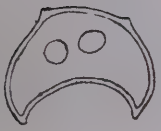

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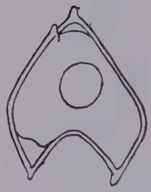

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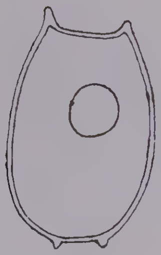

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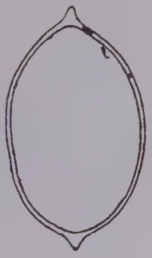

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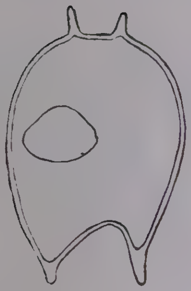

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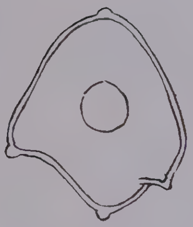

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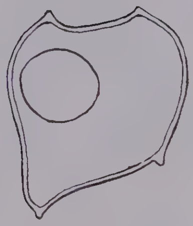

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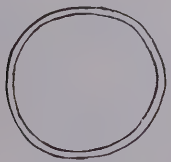

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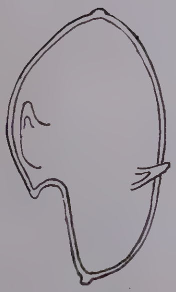

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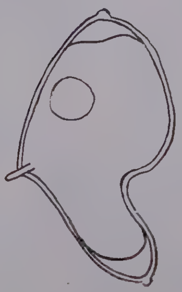

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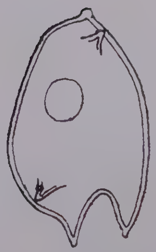

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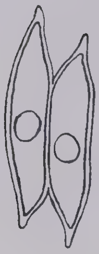
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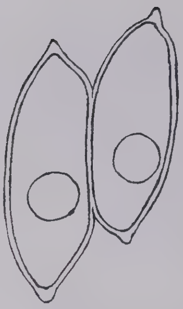
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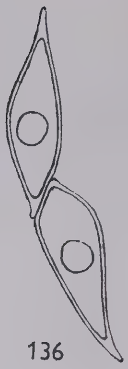
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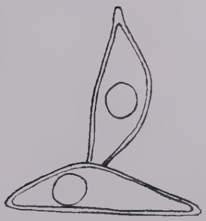
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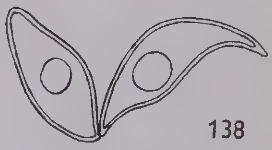
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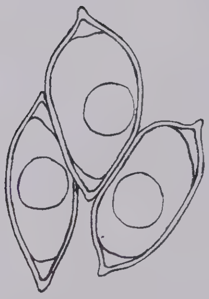
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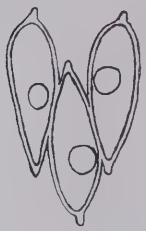
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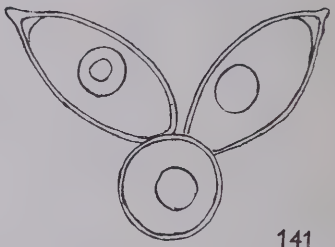
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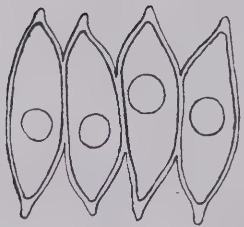
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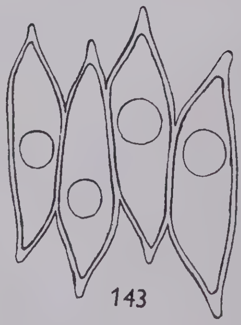
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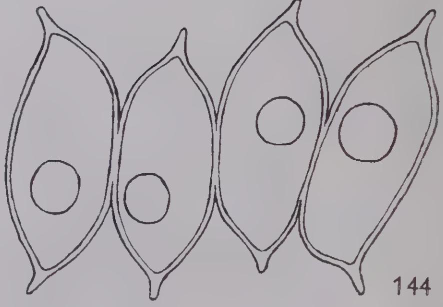
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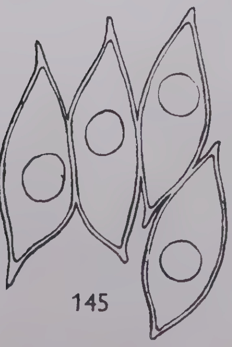
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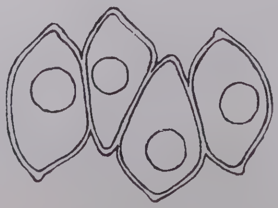
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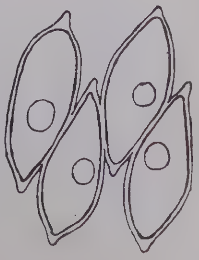
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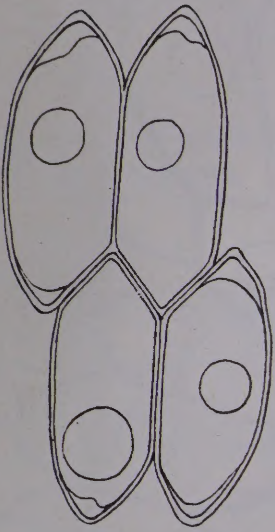

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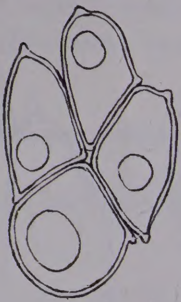

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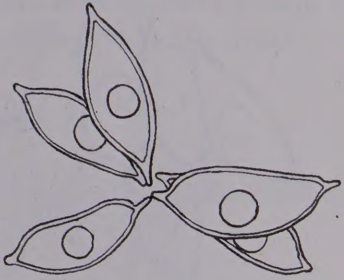

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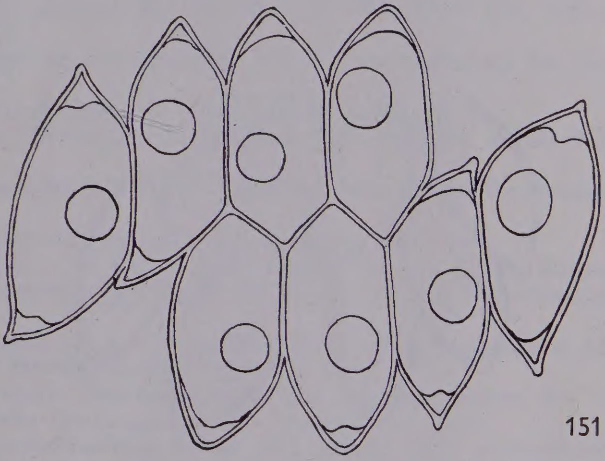

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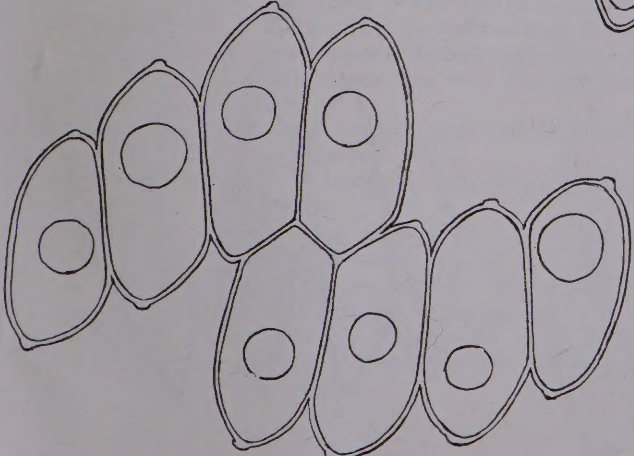

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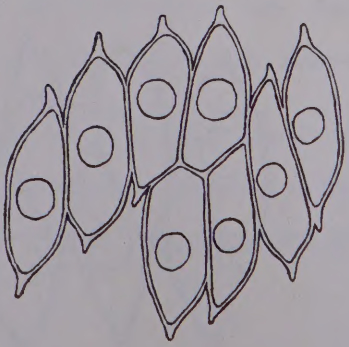

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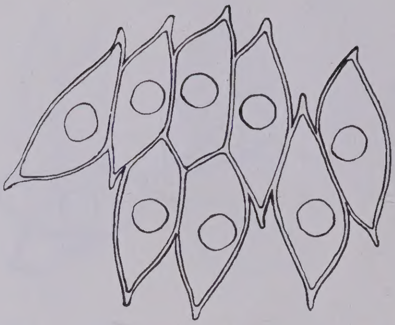

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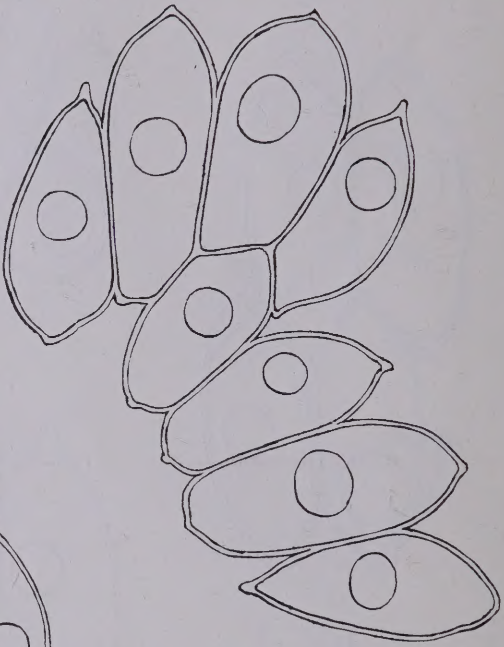

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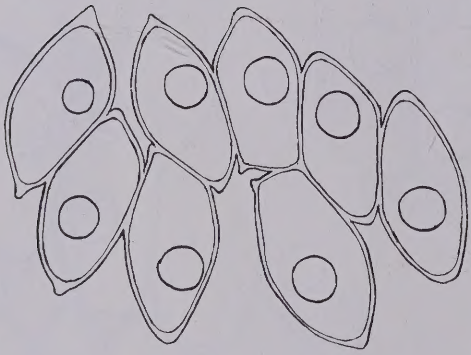

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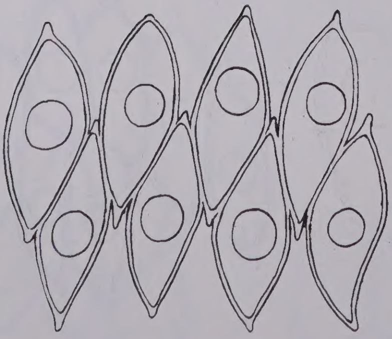

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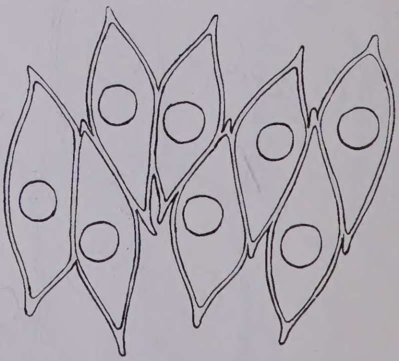

158

Among the abnormalities, there were some specimens originating from unicells (Figs 68—85); from two cells representing incomplete or faulty division (Figs 86—126), and others having a multicellular aspect (Figs. 130—133). Although abnormal forms were common and easily observed from every month of the growing season, they were most numerous during July.

Acknowledgement

We wish to thank Dr. H. Ettl for examining much of the volvocalian material listed herein.

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